~Part 2: Second-Generation Designers~

Langdon Bennett, David Jablonski, Brian Lansrud-Lopez, and John Scott
with Bob Webster

Part 2 is compiled from interviews with the Lab's "second-generation" designers and discussions at the Designers Roundtable, 2nd Los Alamos Primer lectures (July 2013). Their perspectives offer insights into the challenges they face as stewards of the aging U.S. nuclear stockpile in an era when they cannot test it, their resources are limited, and the number of important experiments they need to do is constrained.

***NSS:* What's it like being a second-generation weapons designer?**

John Scott: Sometimes we in the design community have debates about what makes a designer. What makes a designer today is different than what it was before the testing ban. Today, designers make predictions regarding the performance of the aging weapons in the nuclear stockpile, but they can't test their predictions with an underground nuclear test. So some people say we're not really designers.

David Jablonski: There are some people who believe that the only "real" designers are the ones who designed a nuclear weapon that was tested with a full-scale test. By that definition, "real" designers are "the ones who dug big holes" [at the test site in Nevada].

So there are very few "real" designers left in the nuclear weapons complex. Remember, a new U.S. nuclear weapon hasn't been manufactured since about 1991. And since the United States stopped conducting full-scale tests of its weapons in 1992, the first-generation weapon designers, the ones who took part in the testing, are getting scarce—they're retired or getting ready to retire.

In the early 1990s basically everyone in my division at the Lab had nuclear testing experience. Since that time it's been dropping. And that drop has accelerated a lot since I got here. When I came here, in 2002, I'm guessing there were 15 or 20 designers with test experience; today there are maybe 5 or less.

As a result, particularly in the past 15 years, there's been a focus on learning from the first generation while they're still around. Today, we're starting to hire what will become the *third generation* of designers—those who won't have *any* access to designers with underground testing experience. So by and large, they'll be trained by designers who aren't designing [creating new designs] and who don't have any nuclear testing experience.

__Langdon Bennett__ joined Los Alamos in 1996 as a specialist in high-explosives modeling. He currently is the primary lead for the B61 thermonuclear gravity bomb life-extension program (LEP).

__David Jablonski__ joined the Laboratory in 2005 as a physicist. He first came to the Lab in 2002 on an Air Force assignment but then left the Air Force work at the Laboratory on the Stockpile Stewardship Program.

__Brian Lansrud-Lopez__ joined Los Alamos in 2005 as a nuclear engineer. In 2010 he joined the team working on the B61 LEP. His work includes leading hydrodynamic experiments and doing weapons physics research.

__John Scott__ joined Los Alamos in 2000 as a nuclear engineer. In 2006 he became a lead designer for the Reliable Replacement Warhead project. Scott's current work is related to investigating the potential use of recycled plutonium pits in refurbished nuclear weapons.

In lieu of testing nuclear weapons, second-generation designers judge the condition of the aging stockpile based on tests of weapon subsystems, computer simulations of both physics phenomena (shown here) and weapon behavior, and knowledge gained from past nuclear tests. (Photo: Los Alamos)


Langdon Bennett at the Designers Roundtable (Photo: Los Alamos)

Brian Lansrud-Lopez: There are those who believe the second generation should be called "weapons analysts." That's because there is an overriding military philosophy about the stockpile: please, don't change it very much. This is what it looks like, and they like the way it looks. It's old, but it was tested and certified. So in that sense, for the Stockpile Stewardship Program, we're analyzing the stockpile.

Instead of a weapons analyst, I prefer being seen as a "weapons physicist." Any particular weapon design is a concrete example of a concept in weapons physics that's brought to life. Our second-generation responsibility is that we understand weapons physics well enough that we know how and why the designs in the stockpile are going to function and well enough that we can look for problems due to aging and seek solutions. We can't analyze a weapon in the stockpile without being weapons physicists.

Jablonski: In the life-extension programs (LEPs) we've done since the end of testing, we've tried to keep the weapons as close to their original designs as possible. But there's clearly a limit to how far we can do that. The suppliers of some weapons' components have, after 30 years without a market, gone out of business. To make those components today, we'd have to start all over. But replicating the *exact* ways certain source materials were made, and how components were made using those materials, may not be possible in some cases. The people are gone. The tools are different. So the things we replace may look the same but really are not *exactly* the same. The goal of course is to make the necessary changes while minimizing change.

***NSS:* The first-generation designers talked about how quickly they got to do experiments and tests. What's been your experience?**

Lansrud-Lopez: In comparison to Wall, Pedicini, and Mercer-Smith's immediate involvement in nuclear tests, we started by learning the simulation tools. We're given a computer and taught how to run the codes. It's a hard job. Today, integrated experiments on weapon subsystems, for example, hydrotests, are largely out of the question in a designer's formative years. It was six years before I was the lead physicist on a hydrotest. I started that experiment in 2010, and it probably won't be done until January 2014.

We need to get new designers off their computer screens. We need them to be doing tough experiments instead.

The hydrotests we do aren't groundbreaking. They're focused on analyzing the stockpile. We're typically looking at things that are already very well understood. Frankly, we're supposed to get the answers the first-generation designers got—because the stockpile better not change very much. These experiments are very mundane.

Langdon Bennett: Today, with the reliance being more on computer codes and less on experimentation, it takes years before we can give the new designer some reality through an experiment. We're moving too slowly in throwing people into the deep end of the pool. We need to get them off their computer screens. We need them to be doing tough experiments instead of just doing another validation experiment on a B61 LEP.

We need to accelerate the learning process. After a year or so, the newcomers need to be conducting basic experiments and comparing their predictions with their experimental results. They need to get to the point, much faster than they do now, where they're ready to do big experiments, with big unknowns and the opportunity to explain something new.

Without nuclear testing, how do I know that aging, stockpiled weapons will work on my missiles on my submarines?

~U.S. Navy officer

Today, the new hires must commit two to three years to the Lab's Theoretical Institute for Thermonuclear and Nuclear Studies [the Laboratory's in-house weapons design course]. So it's 5 to 6 years before they're doing even a mundane hydrotest, which just verifies something we know, and 10 years before they're allowed to do an experiment that pushes our frontiers, an experiment not guaranteed to succeed.

***NSS:* What other challenges does a second-generation nuclear weapons designer face if they can't design, build, or test nuclear weapons?**

Bob Webster: It makes it harder for our designers to understand and model foreign weapons designs. The country faces threats from the development of improvised terrorist nuclear devices and from the nuclear weapons designed by other nations. We need to know what's going on in those nuclear weapons programs. There are very likely to be ways of building bombs that are different from anything we've thought of. According to a report published by the National Academy of Sciences in 2013, understanding and evaluating the threats from other countries' novel designs "is of vital importance," and "the need to understand their science and technology in detail is likely more compelling today than it has ever been."

I think if we don't try designing new weapons, at the very least on paper, we won't find out what we don't know. If we don't have some idea of what other nations could be designing, what their weapons are capable of and how we might counter them, we'll be in for a surprise.

Scott: We face a *credibility* challenge with the military. The real question is not just *How do we know we're right?* It's *How do we convince others we're right?*

When we say, "Device A will perform with X kilotons," how do we get the military, our allies, and our adversaries to believe us without a nuclear test? The military says, "Why should we believe you? We test all our stuff. You haven't tested yours."

That's the most difficult question we have to face today with the military, DOE headquarters, JASON [an independent group of scientific advisors to the U.S. government on matters of science and technology], and SAGSAT [Strategic Advisory Group Stockpile Assessment Team, which provides technical expertise to U.S. Strategic Command on nuclear weapons issues]. A high-ranking U.S. Navy officer asked us after the Designers Roundtable, "Without nuclear testing, how do I know that aging, stockpiled weapons will work on my missiles on my submarines?"

How *do* I convince military officers like him? We're really grappling with that right now. We're being asked to do the same job the first-generation designers did—ensure that the U.S. nuclear deterrent works—but without testing. When we rebuild anything in the stockpile, we have to change something. Materials don't exist anymore, or the manufacturing process doesn't exist anymore, and we have to make things differently. Even small changes can have large effects. How can we promise the military things will work as they're supposed to?

So we're asking the military to believe us without the same hard evidence they got before. The DoD goes through a very long process to develop the F-35 Joint Strike Fighter. They have test pilots fly the plane, and they work out the kinks. But what if they built the plane without testing it and trained the future pilots using a simulator of the plane, then told the pilots to get into the cockpit and fly a mission?

That's equivalent to what we're being asked to do. We're rebuilding a weapon but can't test it. We're being trained to be able to design and build a weapon in the future, but we're not allowed to practice those skills, except using a computer simulation. We're expected to be *ready* to do it should the need arise, but we *can't* do it before then. We have an enormous responsibility for national security, but at the same time, it's like our hands are tied.

Brian Lansrud-Lopez (Photo: Los Alamos)

I don't think the DoD gets that. We can't practice in order to show them what we can do, and then they have a hard time believing us when we say we can do it. Without practice, we have a hard time believing *ourselves* some of the time. We're under the political constraint where we can't do nuclear testing, but there are key people who haven't acknowledged the consequences of that constraint. So part of our job is to educate people about the consequences of that constraint, and how it affects us—and them—and how we try to succeed within those limitations. That's what stockpile stewardship is all about.

NSS: How can your generation of weapons designers meet this credibility challenge?

Bennett: Send us some people from the military so they can "watch the sausage being made." They'll have a chance to listen to us debating about whether we've made the right judgment, and why we think so. We need to be transparent and learn to explain things in ways our customers can understand. They need to understand all about our assumptions and approximations. They need to see what goes into making a judgment call, how we debate and how we reach a consensus, so they'll have confidence in our work.

Scott: We'll go a long way toward gaining credibility if we can solve the mysteries surrounding historical test failures, the anomalous results that the older designers couldn't explain.

Send us some people from the military so they can "watch the sausage being made."

Webster: I want to point out that we've always had to convince our customers that we were credible, and they've trusted us in the past. For example, Los Alamos never tested every variation of the weapons it designed for the stockpile. We said that, in our best judgment, these variations would work, and the customers believed us. But they trusted our judgment because of hundreds of previous tests that demonstrated our honesty and integrity and credibility.

John Scott at the Designers Roundtable. *(Photo: Los Alamos)*

Jablonski: We're asking to be able to do as many experiments as possible, both to broaden our understanding and to train us. We need to do experiments—lots of them—but we need to do them on tough stuff—and tough stuff that matters. For example, it would be great to do *one shot a week* at DARHT. It's an absolutely wonderful facility with awesome capability. If we could do one experiment a week, think of all the experience we could get. (See sidebar, opposite page.)

And we need other facilities where we can do the tough experiments, for example, to better understand aging plutonium. Together, these experiments would build confidence in the stockpile *and* build confidence with our customers that they can trust our judgment.

Lansrud-Lopez: We really need a new and important kind of experiment that would help us decide if we could reuse older pits. There are no experiments to measure the neutron-generation characteristics of an imploding aged pit—to confirm if these pits will, indeed, go supercritical. It should be possible to do this with a new type of experiment, one we're calling a neutron-diagnosed subcritical experiment, to do this. (See "What Is a Neutron-Diagnosed Subcritical Experiment," p. 34)

Equally important, we have to be allowed to do experiments that run the risk of *failing*, of not meeting our predictions and therefore challenging our judgment. It's those kinds of experiments that would build our credibility. Using neutron-diagnosed subcrits to study new variations of old designs would do just that.

We need to fail and then try to understand why we failed—that's how science works.

Scott: Designers are scientists, so our work relies upon the scientific method. We identify a problem, make a hypothesis, conduct an experiment to test the hypothesis, and then use the experimental results to improve it. So conducting experiments is a crucial part of the scientific process; that's how we advance our scientific understanding. Some experiments yield results that affirm our hypothesis, indicating that our understanding is correct, while others contradict it. But when the experimental results don't match up with our expectations, it's not a failure; it's an opportunity for us to understand something that we clearly didn't understand before the experiment. We need to fail and then try to understand why we failed—that's how science works.

Experimental success is never guaranteed, but we operate today in a business environment where we're asked to guarantee success, where we're allowed no risk of failure. That's not logical. We need to be able to fail and have the scientific integrity to state what we know and what we don't know. That's honest. Honesty builds trust. We need our customers to have trust in us, to trust our judgment.

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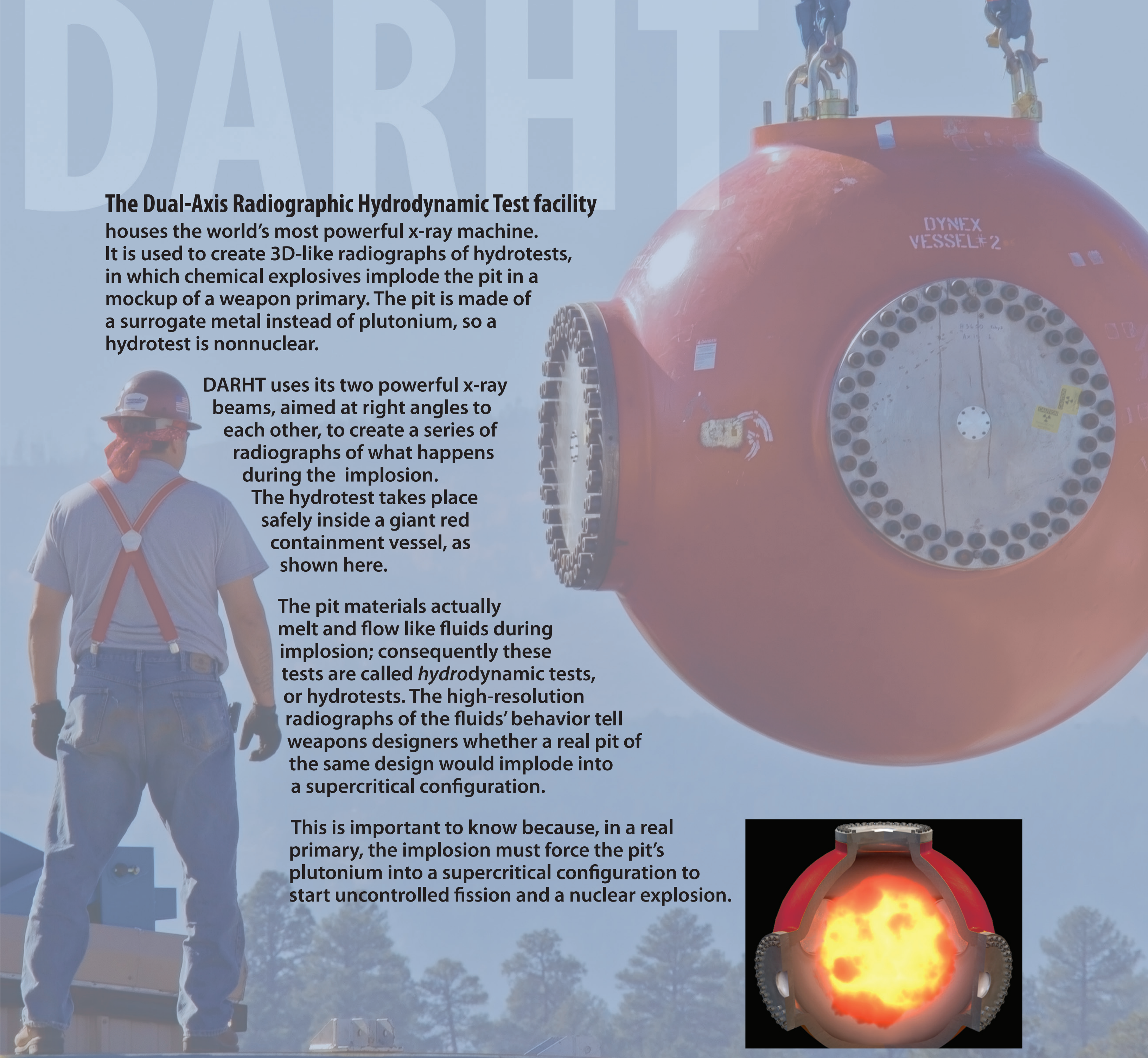
DARHT

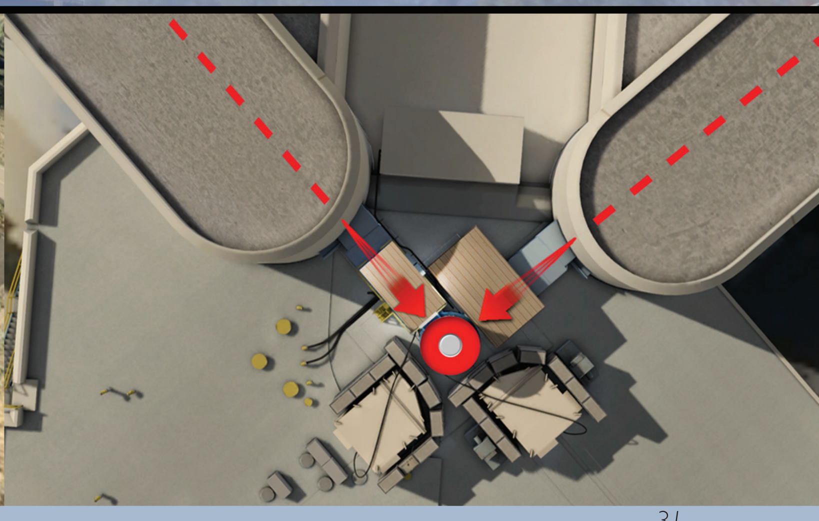


The Dual-Axis Radiographic Hydrodynamic Test facility houses the world's most powerful x-ray machine. It is used to create 3D-like radiographs of hydrotests, in which chemical explosives implode the pit in a mockup of a weapon primary. The pit is made of a surrogate metal instead of plutonium, so a hydrotest is nonnuclear.

DARHT uses its two powerful x-ray beams, aimed at right angles to each other, to create a series of radiographs of what happens during the implosion. The hydrotest takes place safely inside a giant red containment vessel, as shown here.

The pit materials actually melt and flow like fluids during implosion; consequently these tests are called *hydro*dynamic tests, or hydrotests. The high-resolution radiographs of the fluids' behavior tell weapons designers whether a real pit of the same design would implode into a supercritical configuration.

This is important to know because, in a real primary, the implosion must force the pit's plutonium into a supercritical configuration to start uncontrolled fission and a nuclear explosion.



David Jablonski (Photo: Los Alamos)

Jablonski: Yes. Failure is an important part of what we do. Let's say we do an experiment, and we come up with totally different results than we expected. This can be fantastic because it shows us what we don't understand. But today there's a tendency to think of failure as "bad" when it's really an opportunity to fix something that clearly we had wrong. Failure is how we get better at what we do.

The stockpile is changing. Deterrence needs people who can do the science and mitigate the problems in the future stockpile.

Lansrud-Lopez: When you get something wrong, that's a real truth teller. Mother Nature just gave you a wake-up call. Now you've got some serious work to do to figure out why.

***NSS:* What's keeping you from doing more experiments?**

Bennett: Driven in part by our customers, the Laboratory now has a huge problem due to risk aversion. We aren't being given the freedom to do an experiment because of the risk that it might fail. And there's also the risk aversion stemming from excessive safety concerns. Some of these concerns reflect, I think, a lack in common sense. The result is excessive regulation and bureaucracy at the Laboratory. Excessive safety regulations, along with a bloated bureaucracy, drastically increase both the cost of experiments and the time it takes to conduct them.

Jablonski: Bureaucracy definitely gets in the way. It's not ill intentioned, but it blocks us from doing our technical work. Meetings are often valuable, but all of a sudden it's three in the afternoon, and the technical work has to wait another day. There has to be a cost-benefit analysis: bureaucracy balanced with getting the job done.

***NSS:* Do you have confidence in the stockpile?**

Jablonski: Yes, absolutely. We have a suite of more than 1,000 nuclear tests whose data tell us that our devices work just fine. And we have post-test-ban experiments and our computational tools. When we've found issues related to aging, we've been able to address them with our LEPs. These, together with the judgment of lots of other expert scientists and engineers, give me confidence.

Bennett: I have a great deal of confidence in the stockpile as it exists now. But because of aging and replaced components, this stockpile is different than it was a couple of decades ago, and there'll be a different stockpile again tomorrow. How will we have confidence in it then? We need to keep stewarding it and doing surveillance on it. We need to keep doing experiments to see how the weapons age and how we can mitigate the aging process. We can't just swap out old parts with new ones that are made differently and let it go at that. It's not that simple.

Scott: Without testing, our confidence is based on our assessments of the weapons. To make assessments, we rely on the interplay between computer simulations and experiments. We designers say, "The codes always lie." To make the codes more accurate, we conduct experiments and adjust the codes accordingly. This interaction between experiments and computer simulations is what gives us the confidence to say that, as of today, the aging weapons will work as designed.

Lansrud-Lopez: If we want to know positively how our nuclear stockpile will work, we obviously should be doing nuclear tests. We recognize that we can't do full-scale tests, so we are trying to do the best we can with what we've got. Today, our deterrence rests upon *science* and the *people* who do it.

Webster: We get a lot of pushback from our customers when we talk about the "value of doing science." They tend to want just those experiments that are directly about the stockpile, that keep the stockpile looking just like it did 20 to 30 years ago.

Bureaucracy definitely gets in the way. There has to be a cost-benefit analysis: bureaucracy balanced with getting the job done.

But the stockpile *is* changing due to aging and our replacement of aged components with new ones made in new ways, with new materials. Deterrence needs people who can do the science that can predict and mitigate the problems in the *future* stockpile—it needs designers with judgment who, without testing the weapons, can predict how the weapons will perform down the road.

We're going to have to educate our customers about what it takes to train new designers: more experiments, more science.

As Vic Reis, the architect of stockpile stewardship, said during the 2nd Primer lectures, "The issue is this: the key to deterrence is not just the weapons, it's the scientists and the science. This is very hard for the DoD to understand. If we don't have full-scale testing and if the DoD relies on its LEPs, then deterrence ultimately rests on *the science and the people with judgment*."

Yuri Trutnev, the Russian who co-developed the Soviet's 50-megaton weapon—the most powerful nuclear weapon ever detonated—said to Vic one night over a drink, "The reason we did all those nuclear tests was not to test the weapons, but to *test the designers*. We could then tell how good they were."

Vic said, "The Russians get this, but not the DoD or the NNSA. We need to educate our customers about how people and science integrate into our deterrence posture. They're not something separate."

He paused, pointed at the audience, and said, "*They're where the rubber meets the road*."

~Dominic Martinez

John Scott (left) and David Jablonski in front of the Strategic Computing Center, the home of Los Alamos' supercomputers. (Photo: Los Alamos)

Highly trained technicians at the Nevada National Security Site maintain a high-intensity x-ray machine at the U1a experimental facility, built at the bottom of a shaft almost 1,000-feet deep. If approved, neutron-diagnosed subcritical experiments would be conducted at U1a. (Photo: National Nuclear Security Administration)

What Is a Neutron-Diagnosed Subcritical Experiment (NDSE)?

It would be a special kind of hydrotest. An NDSE would test the quality of a real nuclear trigger—the plutonium pit—by testing how well it implodes *and* predicting its ability to go supercritical. Previous subcritical experiments have provided scientific data for understanding the physical properties of plutonium, but NDSEs could also tell us about the pit's ability to generate enough neutrons to go supercritical and about how effectively it does it. For a weapon to detonate, a supercritical state is where the real action is, so the Lab needs to understand how a pit goes supercritical.

How Would an NDSE Work?

Other subcritical experiments use a scaled-down plutonium pit. These pits are used because it is physically impossible for them to generate enough neutrons to go critical (and thus not supercritical). This advantage is also a disadvantage: without enough neutrons being generated, neutron generation—the key to a nuclear detonation—cannot be tested.

An NDSE, however, could use a *real* pit, identical to the ones used in a weapon, except this pit would be modified: it would generate more neutrons than in a typical subcritical experiment but still *not enough to go critical*. (There are several ways that a pit can be modified to prevent it from going critical.)

During the implosion neutrons from an external source would be sent into the pit. There would be just enough of these external neutrons to make the pit "think" it is still a normal pit and start to behave like one. In contrast to a critical system that grows the number of neutrons exponentially, a pit in an NDSE would generate more of its own neutrons in proportion to the number of external neutrons sent in. Because the number of neutrons sent in would be controlled, the number of neutrons the pit would generate in response would also be controlled. An NDSE is an exquisitely precise experiment.

The pit's ability to generate neutrons at the subcritical level would be measured and the result extrapolated to infer how the pit, if not modified, would perform. That is, the measurement could reveal whether or not an unmodified pit would generate enough neutrons to go supercritical. Because the pit's ability to generate enough neutrons to go supercritical is a function of the pit's design and manufacture and of the quality of its plutonium, an NDSE would, by determining the pit's neutron production, also provide critical information about a pit's characteristics.

Why Are NDSEs So Important?

NDSEs could help weapon designers answer, about plutonium pits, key questions they cannot currently answer without testing. For example, will an implosion using aged plutonium pits or using newer pits designed and manufactured using new processes be good enough to trigger a nuclear explosion that meets military requirements?

Today second-generation designers are already asked these questions by their customers, including the military. The designers run supercomputer simulations that help provide a basis for their answers. But how do the designers, or their customers, know the simulations are correct? An NDSE could corroborate their simulations.

In addition, designing an NDSE, and designing supercomputer simulations that successfully match the experiment's outcomes, could train second-generation weapons designers in how to reuse plutonium pits in the life-extension programs for current stockpile weapons. NDSEs could test their judgment and credibility when making predictions about pit performance.

In short, NDSEs could offer second-generation designers a way to answer, without testing, key questions regarding the implosion performance of plutonium pits. Equally important, these experiments would provide the designers the opportunity to design and execute the kind of experiments that would demonstrate their judgment and predictive skills, and so build their credibility with their customers and peers.